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BRIEFER ARTICLES

THE PHYSIOLOGICAL CONDITIONS FOR THE DEVELOPMENT OF MONOECIOUS PROTHALLIA IN ONOCLEA STRUTHIOPTERIS[1]

The following investigation was undertaken with the view of ascertaining the validity of the statement made by CAMPBELL concerning the dioeciousness of *Onoclea Struthiopteris*. He says: "In the genus Onoclea, as well as some other Polypodiaceae, the prothallia are regularly dioecious, and only a part of them develop the archegonial meristem. The others remain one-layered, and are often of very irregular form, and may be reduced to a short row of a few cells. All of the 'ameristic prothallia,' as PRANTL calls them, are males. In the majority of the Polypodiaceae these occur more or less plentifully, and are often the result of insufficient nutrition; but in Onoclea it is something more than this, as not only the small prothallia are males, but the large ones are exclusively females, and not hermaphrodite, as in most ferns."[2]

The development of fern prothallia, and their reproductive organs, has been studied until recently more from the morphological than the physiological point of view. Much of the work of physiological importance demonstrates the effect of various light intensities. PRANTL (in 1881) was one of the first to investigate carefully the effect of nutrition. His observations upon cultures of *Polypodium vulgare*, *Aspidium filix-mas*, *Ceratopteris thalictroides*, and *Osmunda regalis* led him to draw the following conclusions: that the food supply determines the development of the prothallia and the separation of the sexual organs; that good cultural conditions favor the production of meristem and the development of archegonia; that poor cultural conditions retard the production of meristem and favor the development of antheridia; that as nitrogen is one of the requisites of a good cultural condition, an insufficient nitrogen supply may be the cause of thickly grouped prothallia bearing only antheridia.

The spores of *Onoclea Struthiopteris* used in the experimental work were collected from yards about Ann Arbor in September and sown soon after collected. Cultures were made upon soil in porous clay pots, and in sterilized distilled water.

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[1] Contribution No. 114 from the Botanical Department of the University of Michigan.

[2] Mosses and ferns. Edition 2. p. 314.

Germination began in the soil cultures, four to six days after the spores were sown. Six weeks later, antheridia and archegonia appeared. As the genus Onoclea has been considered by most writers to be dioecious, it was interesting to find monoecious prothallia occurring in about 1 per cent. of the soil cultures; the other prothallia seemed regularly dioecious. The monoecious prothallia were of medium size, slightly heart-shaped, with a meristem bearing the archegonia; the antheridia, fewer in number than the archegonia, developed from the marginal cells. Some of the dioecious prothallia were large, heart-shaped, with a meristem bearing many archegonia; others were smaller, filamentous, slightly heart-shaped, or very irregularly shaped. These prothallia were one layer of cells in thickness, lacked a meristem, and the antheridia were formed both from the marginal and ventral cells.

The development of the prothallia did not seem entirely influenced by their position, as indicated by PRANTL, for many of the smaller prothallia, the "ameristic" ones, were found in the less crowded regions; while the larger prothallia, the "meristic" ones, bearing only archegonia, were often found in the more crowded regions.

An attempt was made to produce monoecious prothallia through the influence of an inorganic solution. For this purpose large, heart-shaped prothallia with archegonia in various stages of development were selected and transferred from the soil to BEYERINCK'S solution. Four to seven days later, in one-half of the cultures examined, a number of monoecious prothallia were found, antheridia having developed from the marginal cells of the prothallia, near the notch. In all cases, death of the prothallia immediately followed, which seemed to be due in some cases to too long exposure to direct sunlight, in others to injury of tissue in transferring from the soil to the solution.

Other cultures were transferred from the sterilized distilled water to solutions and kept in moderately weakened light. Two to four weeks later, in these cultures, *the majority of the prothallia became monoecious;* numerous antheridia were produced, both from marginal cells and from the ventral surface cells on the sides, and near the apex of the prothallia. Other prothallia gave rise to numerous proliferations; some were mere filaments bearing antheridia at their apices; others had the thallus form, were distinctly notched, and produced antheridia from the marginal and ventral surface cells.

After all the prothallia needed for experimental purposes had been removed, the pots were set aside and neglected for about two weeks. At the end of this time, the surface of the soil was brown, and all the prothallia appeared dead. The pots were then kept moist under bell jars in weakened light. After a period varying from six to eight weeks, many of the old prothallia had developed adventitious outgrowths. Some of these outgrowths were filaments or irregularly shaped prothallia covered with antheridia. Others developed into elongated prothallia bearing archegonia, which in turn frequently became monoecious by developing adventitious shoots bearing antheridia.

Germination began in the sterilized water cultures four days after the spores were sown. Six days later the prothallia had attained a growth of ten cells. A set of cultures was then made, by transferring 100 prothallia to each of several nutritive solutions. For each of these sets a control set was kept in sterilized distilled water. Six weeks after the prothallia had been transferred to the nutritive solutions, male prothallia bearing antheridia and female prothallia bearing archegonia were observed in about equal proportions. The prothallia were regularly dioecious, and at this time no monoecious prothallia were observed. That these antheridia and archegonia were functional is shown by the production of vigorous young sporophytes. One of these sporophytes lived five months in KNOP'S solution, and developed five fronds, one of which was 2.5^{cm} in length. Twelve weeks after the transference of the prothallia to the nutritive solutions, many monoecious ones were observed in the cultures of KNOP'S solution. These first developed the meristem with archegonia, afterward antheridia were formed from the marginal and ventral cells of the adventitious outgrowths.

CAMPBELL (*l. c.* 321) makes the statement that "as soon as an archegonium is fertilized, no new ones form, but it frequently happens that a very large number prove abortive before finally fertilization is effected." In all the cultures examined, both from the soil and the nutritive solutions, frequently prothallia have been observed producing new archegonia after fertilization had taken place. In the solution cultures young archegonia, antheridia, and sporophytes were present at the same time upon the same prothallia.

A further attempt to produce monoeciousness was made, by transferring prothallia bearing archegonia from one nutritive solution to another. Results were obtained in the following cultures: (*a*) from KNOP'S solution to BEYERINCK'S solution, lacking potassium dihydrogen phosphate; (*b*) from SACHS'S solution with 1 per cent. potassium phosphate, to KNOP'S solution. In these cultures, three to four weeks after the transfer had been made, monoecious prothallia were observed. The prothallia continued to grow for ten to eleven weeks and developed many adventitious outgrowths bearing antheridia. Young sporophytes were also developed.

In summing up, therefore, it may be said: monoecious prothallia, as well as dioecious prothallia, were observed in soil cultures; monoecious prothallia were obtained from "female" prothallia transferred at a ten-celled stage from distilled water to KNOP'S solution; monoecious prothallia were obtained by transferring "female" prothallia from the soil to a nutritive solution; they were also obtained by transferring prothallia from one nutritive solution to another.

The experimental work of this paper was done in the botanical laboratory of the University of Michigan. I wish to express my indebtedness to Dr. C. H. KAUFFMAN, who suggested the problem and under whose guidance and inspiration the work was carried on.—ELIZABETH DOROTHY WUIST, *University of Michigan.*

CECIDOLOGY IN AMERICA

Botanists are usually interested in the malformation of plants, and some of the earliest literature contains references to these abnormal structures. However, cecidology is one of the latest of the biological sciences to be developed. The literature is so involved with other branches of biology that only those who have given special attention to the subject can have a very clear conception of the dimensions of modern cecidology and the character of its problems. The entomologists have given far more attention to the subject, in both Europe and America, than any other group of scientists. For this reason many have come to consider cecidology as a branch of entomology, while as a matter of fact the entomologist has much greater interest in the insects than in the galls.

Cecidology now includes all hypertrophies caused by specific organisms, as insects, nematodes, fungi, and bacteria. It has been suggested that the term "gall," which has been in use since the sixteenth century, be discontinued and the word *cecidium* be substituted; also that the structures caused by these different organisms be designated as diptero-cecidia, phyto-cecidia, nemato-cecidia, myco-cecidia, etc. Some writers have been inclined to include that very much confused and mysterious class of diseases known as teratology under the head of cecidology, and there appears to be no conclusive argument as to why it should or should not be so considered.

The early literature is so thoroughly involved with other subjects as to be practically unavailable to the general students, many valuable references